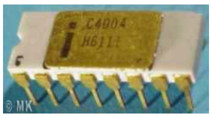
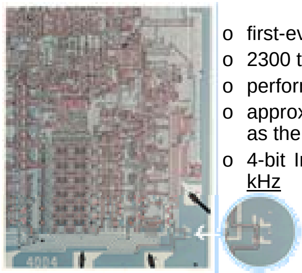
CHAPTER 1

A VERY BRIEF HISTORY OF MICROPROCESSORS & MICROCONTROLLERS

Intel 4004



- Introduced in 1971.
- Federico Faggin design.



- first-ever single-chip microprocessor
- 2300 transistor
- performs 60,000 operations / second.
- approximately the same performance as the 18,000 vacuum tube ENIAC.
- 4-bit Intel C4004 clock Speed is 108 kHz

Intel 8008

- 1972: Faggin begins work on an **8-bit processor, the Intel 8008**. The prototype has serious problems with electrical charge leaking out of its memory circuits.
- Intel's 8008 is well-received, but system designers want increased speed, easier interfacing, and more I/O and instructions. The improved version is 8080.

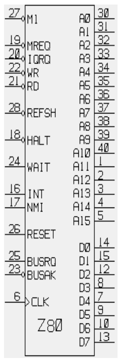
Zilog Z80

- Faggin leaves Intel to start his own company **Zilog**, who later produce the **Z80**. 3.5MHz Z80 is a very popular processor taught in many universities)

- … and, later, a 16-bit Z8000. But INTEL is getting more powerful.

The Zilog Z80

- The Z80 is an 8 bit CPU with a 16 bit address bus capable of direct access of 64K of memory space.
- It was based on the 8080; it has a large instruction set.
- Programming features include an accumulator and six eight bit registers that can be paired as 3-16 bit registers. In addition to the general registers, a stack-pointer, program-counter, and two index (memory pointers) registers are provided.
- It had a 40 pin DIP package manufactured in A, B, and C models, differing only in maximum clock speed. It was also manufactured as a stand-alone microcontroller with various configurations of on-chip RAM and EPROM.
- It proves useful for low cost control applications.



Early Microcontrollers

- 1974: **Motorola** (originally car radio manufacturers) had introduced transistors in the 1950s and decided to make a late but serious effort in the microprocessor market. They announced their 8-bit **6800** processor.
- 1975: General Motors approach Motorola about a custom-built derivative of the 6800. Motorola's long experience with automobile manufacturers pays off and Ford follow GM's lead.
- 1976: Intel introduce an 8-bit microcontroller, the MCS-48. They ship 251,000 in this year.
- 1980: Intel introduced **8051**, an 8-bit microcontroller with on-board EPROM. They ship 22 million and 91 million in 1983.
- Early 90s: PIC is introduced to meet a demand for a cheap, small and practical microcontroller which was both easy to use and program.

CHAPTER 2

PIC Peripheral Interface Controller

What is a microcontroller?

Microcontrollers are small computer on a chip with some special properties:

- CPU, code memory, data memory and IO ports all included on a single chip
- Dedicated to one task
- Small and low cost
- Embedded in many consumer devices

Why PIC is popular?

PICs are popular with developers due to
•low cost
•wide availability
•large user base
•extensive collection of application notes
•availability of low cost or free development tools
•serial programming capability.

PIC is very small and easy to implement for not complex problems and usually accompanies to the microprocessors as an interface. For example:

Family Core Architectural Differences

Baseline Core Devices
(ex:12C50x, 16C5x)
•12 bit wide code memory,
•tiny two level deep call stack.
•**33 instructions**
•PIC10, PIC12 & PIC16 devices
•6 pin to 40 pin packages.

Mid-Range Core Devices
(ex:12C50x, 16C5x)
14 bit wide code memory
•improved 8 level deep call stack.
•35 instructions
•increased opcode width allows addressing of more memory
•PIC12 and PIC16 devices.

PIC17 High End Core Devices (Ex:17C4x,17C7xx)
•never became popular and superseded by the PIC18 architecture.
•16 bit wide opcodes (allowing many new instructions) : **58 instructions**
•16 level deep call stack. Packages of 40 to 68 pins.
•a memory mapped accumulator
•read access to code memory (table reads)
•direct register to register moves
•an external program memory interface to expand the code space
•an 8bit x 8bit hardware multiplier
•auto-increment/decrement addressing

PIC18 High End Core Devices (ex:18Cxxx)
•new high end pic architecture
•It inherits most of the features and instructions of the 17 series,
•77 instructions, much deeper call stack (31 levels deep)
•the call stack may be read and written
•offset addressing mode
•a new indexed addressing mode in some devices

PIC24 and dsPIC 16 bit Microcontrollers
•architectures differ significantly from prior models.
•dsPICs are Microchip's newest family (started in 2004)
• digital signal processing capabilities.
•Microchip's first inherent 16-bit (data) microcontrollers.
•hardware MAC (multiply-accumulate)
• barrel shifting
• bit reversal
•(16x16)-bit multiplication
•other digital signal processing operations.
•Can be efficiently programmed in C

PIC SPEED

- Can use crystals, clock oscillators, or even an RC circuit.
- Some PICs have a built in 4MHz RC clock, Not very accurate, but requires no external components!
- Instruction speed = 1/4 clock speed (Tcyc = 4 * Tclk)
- All PICs can be run from DC to their maximum spec'd speed:

12C50x	4MHz
12C67x	10MHz
16Cxxx	20MHz
17C4x / 17C7xxx	33MHz
18Cxxx	40MHz

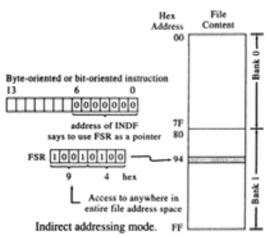
Register Addressing Modes

Immediate Addressing
Movlw H'0F'

Direct Addressing
Uses 7 bits of 14 bit instruction to identify a register file address
8^{th} and 9^{th} bit comes from RP0 and RP1 bits of STATUS register.
Z equ D'2'
btfss STATUS, Z

Indirect Addressing

- Full 8 bit register address is written the special function register FSR
- INDF is used to get the content of the address pointed by FSR
- Exp : A sample program to clear RAM locations H'20' – H'2F'



PIC MEMORY CAPACITY

Device Type	Program size	Data	Registers EEPROM	Pins
PIC16F627	1024	128	224	18
PIC16F628	2048	128	224	18
PIC16F83	512	64	36	18
PIC16C84	1024	64	36	18
PIC16F84	1024	64	68	18
PIC16F84A	1024	64	68	18
PIC16F870	2048	64	128	40
PIC16F871	2048	64	128	40
PIC16F872	2048	64	128	28
PIC16F873	4096	128	198	28
PIC16F874	4096	128	192	40
PIC16F876	8192	256	368	28
PIC16F877	8192	256	368	40

SPECIAL FUNCTION REGISTERS

Register	Address	Bank	Tutorial
EEADR	09	0	25
EECOCN1	08	1	25
EECON2	09	1	25
EEDATA	08	0	25
FSR	04	0-1	16
INDF	00	0-1	16
INTCON	0B	0-1	18
OPTION	01	1	18
PCL	02	0-1	4
PCLATH	0A	0-1	14
PORTA	05	0	4
PORTB	06	0	4
STATUS	03	0-1	2
TMR0	01	0	18
TRISA	05	1	4
TRISB	06	1	4

STATUS REGISTER (16f84)

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **IRP**: Register Bank Select bit (used for indirect addressing)
0 = Bank 0, 1 (00h - FFh)
1 = Bank 2, 3 (100h - 1FFh)
The IRP bit is not used by the PIC16F8X. IRP should be maintained clear.

bit 6-5: **RP1:RP0**: Register Bank Select bits (used for direct addressing)
00 = Bank 0 (00h - 7Fh)
01 = Bank 1 (80h - FFh)
10 = Bank 2 (100h - 17Fh)
11 = Bank 3 (180h - 1FFh)

Each bank is 128 bytes.
Only bit RP0 is used by the PIC16F8X.
RP1 should be maintained clear.

bit 4: **$\overline{TO}$**: Time-out bit
1 = After power-up, CLRWDT instruction, or SLEEP instruction   0 = A WDT time-out occurred

bit 3: **$\overline{PD}$**: Power-down bit
1 = After power-up or by the CLRWDT instruction   0 = By execution of the SLEEP instruction

bit 2: **Z**: Zero bit
1 = The result of an arithmetic or logic operation is zero
0 = The result of an arithmetic or logic operation is not zero

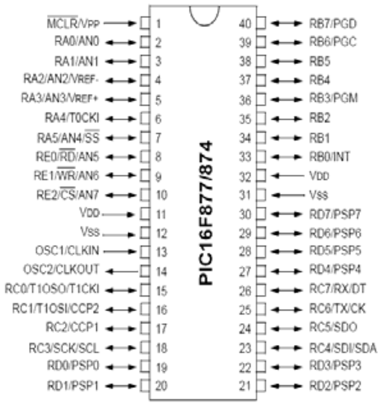
bit 1: **DC**: Digit carry/$\overline{borrow}$ bit (for ADDWF and ADDLW instructions) (For $\overline{borrow}$ the polarity is reversed)
1 = A carry-out from the 4th low order bit of the result occurred
0 = No carry-out from the 4th low order bit of the result

bit 0: **C**: Carry/$\overline{borrow}$ bit (for ADDWF and ADDLW instructions)
1 = A carry-out from the most significant bit of the result occurred
0 = No carry-out from the most significant bit of the result occurred
Note: For $\overline{borrow}$ the polarity is reversed. A subtraction is executed by adding the two's complement of the second operand. For rotate (RRF, RLF) instructions, this bit is loaded with either the high or low order bit of the source register.

SAMPLE PROGRAM

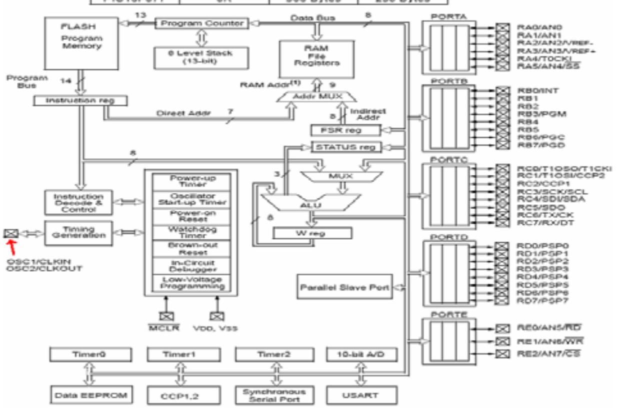
List count deci	Prog count deci	Prog count hex	Code value hex	Source code		
0004	0	0000		STATUS	EQU 3	; name program location 3 as STATUS
0005	0	0000		PORTB	EQU 6	; name program location 6 as PORTB
0006	0	0000				
0007	0	0000			ORG 0	; Reset Vector address
0008	0	0000	28 05		GOTO 5	; go to PIC address location 5
0009	1	0001			ORG 4	; Interrupt Vector address
0010	4	0004	28 05		GOTO 5	; go to PIC address location 5
0011	5	0005			ORG 5	; Start of Program Memory
0012	5	0005				
0013	5	0005	01 86		CLRF PORTB	; clear Port B data pins
0014	6	0006	16 83		BSF STATUS,5	; set for Bank 1
0015	7	0007	01 86		CLRF PORTB	; set all Port B as output
0016	8	0008	12 83		BCF STATUS,5	; set for Bank 0
0017	9	0009				
0018	9	0009	14 06	LOOPIT	BSF PORTB,0	; set Port B pin 0 to logic 1
0019	10	000A	14 86		BSF PORTB,1	; set Port B pin 1 to logic 1
0020	11	000B	15 06		BSF PORTB,2	; set Port B pin 2 to logic 1
0021	12	000C	15 86		BSF PORTB,3	; set Port B pin 3 to logic 1
0022	13	000D	16 06		BSF PORTB,4	; set Port B pin 4 to logic 1
0023	14	000E	16 86		BSF PORTB,5	; set Port B pin 5 to logic 1
0024	15	000F	17 06		BSF PORTB,6	; set Port B pin 6 to logic 1
0025	16	0010	17 86		BSF PORTB,7	; set Port B pin 7 to logic 1
0026	17	0011	01 86		CLRF PORTB	; clear all PORTB pins
0027	18	0012	28 09		GOTO LOOPIT	; go to address LOOPIT

PIC 16F877



- 8 kbytes of FLASH Prog. Mem. (8kx14)
- 368 bytes of Data Memory (RAM)
- 256 bytes of EEPROM Data Memory
- 33 input or output pins
- 20 MHz operating speed(200 ns instruction cycle)
- Max. 25 mA current from an output pin

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



PIC Program Memory

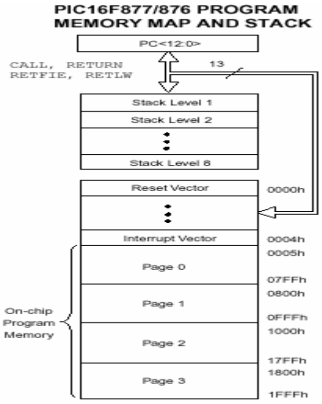
- 12C508 512 12bit instructions
- 16C71C 1024 (1k) 14bit instructions
- 16F877 8192 (8k) 14bit instructions
- 17C766 16384(16k) 16bit instructions

PROGRAM MEMORY

RP1	RP0

(STATUS<6:5>)

= 00 → Bank0
= 01 → Bank1
= 10 → Bank2
= 11 → Bank3



STATUS REGISTER (16f877)

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
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bit 6-5: **RP1:RP0**: Register Bank Select bits (used for direct addressing)
11 = Bank 3 (180h - 1FFh)
10 = Bank 2 (100h - 17Fh)
01 = Bank 1 (80h - FFh)
00 = Bank 0 (00h - 7Fh)
Each bank is 128 bytes

PIC Data Memory

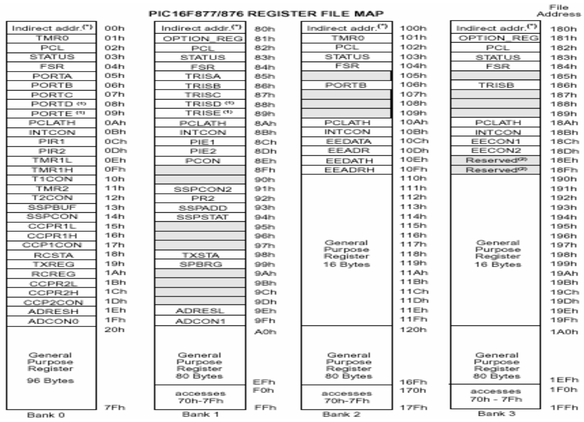
PICs use general purpose "file registers" for RAM (each register is 8bits for all PICs)

Some examples are:

12C508	25 Bytes RAM
16C71C	36 Bytes RAM
16F877	368 Bytes (plus 256 Bytes of nonvolatile EEPROM)
17C766	902 Bytes RAM

Don't forget, programs are stored in program space (not in data space), so low RAM values are OK.

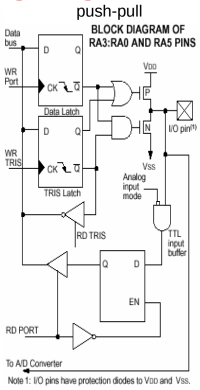
DATA MEMORY



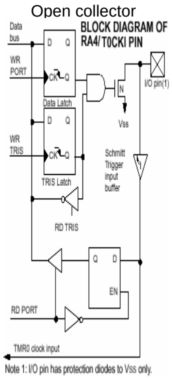
I/O PORTA

```
EXAMPLE 3-1:  INITIALIZING PORTA
BCF    STATUS, RP0  ;
CLRF   PORTA        ; Initialize PORTA by
                    ; clearing output
                    ; data latches
BSF    STATUS, RP0  ; Select Bank 1
MOVLW  0xCF         ; Value used to
                    ; initialize data
                    ; direction
MOVWF  TRISA        ; Set RA<3:0> as inputs
                    ; RA<5:4> as outputs
                    ; TRISA<7:6> are always
                    ; read as '0'.
```

push-pull

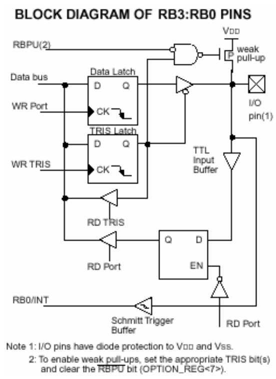


Open collector

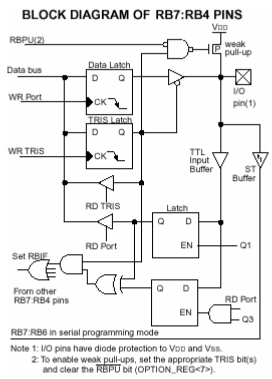


I/O PORTB

High Z inputs



RB7:RB4 Interrupts



CHAPTER 3

PIC PROGRAMMING

Mnemonic, Operands		Description	Cycles	14-Bit Opcode MSb			LSb	Status Affected	Notes
BYTE-ORIENTED FILE REGISTER OPERATIONS									
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	lfff	ffff	Z	2
CLRW	-	Clear W	1	00	0001	0xxx	xxxx	Z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	Z	1,2
DECF	f, d	Decrement f	1	00	0011	dfff	ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f, d	Increment f	1	00	1010	dfff	ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
MOVF	f, d	Move f	1	00	1000	dfff	ffff	Z	1,2
MOVWF	f	Move W to f	1	00	0000	lfff	ffff		
NOP	-	No Operation	1	00	0000	0xx0	0000		
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS									
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AND CONTROL OPERATIONS									
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	$\overline{TO},\overline{PD}$	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk		
RETFIE	-	Return from interrupt	2	00	0000	0000	1001		
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk		
RETURN	-	Return from Subroutine	2	00	0000	0000	1000		
SLEEP	-	Go into standby mode	1	00	0000	0110	0011	$\overline{TO},\overline{PD}$	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
XORLW	k	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z	

Programming PIC 16F877

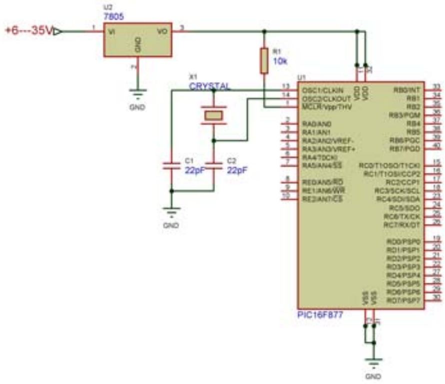
- Assembler (MPLAB)
- Basic (Pic Basic Pro)
- C (HITEC PICC)

```
main()
{
    set_tris_b(0x00);

    while(true)
    {
        if (input(PIN_A0))

            output_high(PIN_B0);

        else

            output_low(PIN_B0);

    }
}
```

```
0007    MOVLW    00
0008    TRIS     6

0009    BTFSS    05,0
000A    GOTO     00D

000B    BSF      06,0

000C    GOTO     00E

000D    BCF      06,0

000E    GOTO     009
```

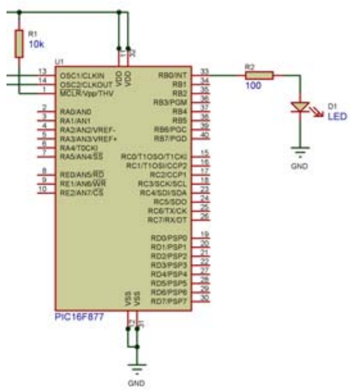
PIC BASIC PROGRAMMING

Minimum circuitry for PIC16F877



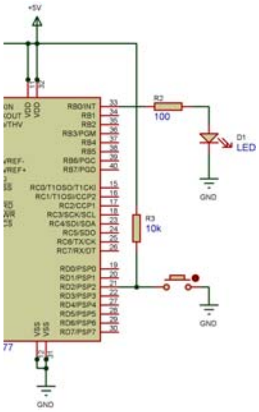
LED (light emitting diode) flasher

```
LOOP:
        HIGH   PORTB.0
        PAUSE  500
        LOW    PORTB.0
        PAUSE  500
        GOTO   LOOP
```



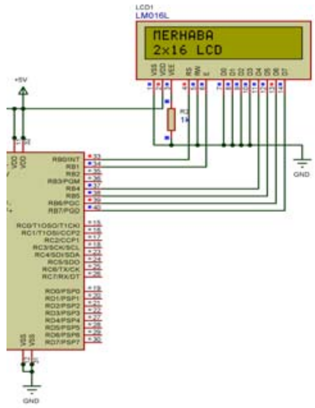
BUTTON READ

```
        INPUT      PORTD.2
LOOP:
        IF PORTD.2=1 THEN
                HIGH PORTB.0
        ELSE
                LOW   PORTB.0
        ENDIF
        GOTO LOOP
```



LCD

```
DEFINE  OSC 4
DEFINE  LCD_DREG PORTB
DEFINE  LCD_DBIT 4
DEFINE  LCD_RSREG PORTB
DEFINE  LCD_RSBIT 0
DEFINE  LCD_EREG PORTB
DEFINE  LCD_EBIT 1
DEFINE  LCD_BITS 4
DEFINE  LCD_LINES 2
DEFINE  LCD_COMMANDUS 2000
DEFINE  LCD_DATAUS 50

LCDOUT  254,1,  "MERHABA"
LCDOUT  254,192,"2x16 LCD"

END
```

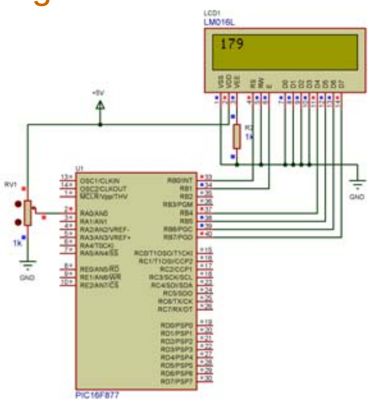


Analog to Digital Conversion

Format: ADCIN *Channel,Var*

Sample Program:

```
 ABC VAR BYTE
 ADCON1=2 'PORTA is
analog
   INPUT   PORTA.0
LOOP:
   ADCIN   PORTA.0,ABC
   LCDOUT 254,1,#ABC
   PAUSE   100
   GOTO    LOOP
```



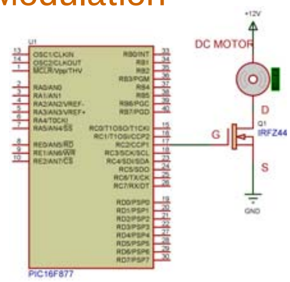
Pulse Width Modulation

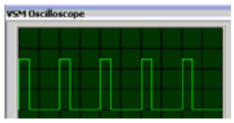
Format:

HPWM *Channel,Dutycycle,Frequency*

Sample Program:

```
DEFINE CCP1_REG PORTC
'Hpwm 1 pin port
DEFINE CCP1_BIT 2
'Hpwm 1 pin bit
HPWM     1,64,1000
' Send a 25% duty cycle PWM
signal at 1kHz
END
```





Pulse Width Modulation

```
    DEFINE CCP1_REG PORTC        'Hpwm 1 pin port
    DEFINE CCP1_BIT 2            'Hpwm 1 pin bit

    DUTY     VAR BYTE
    i        VAR BYTE

DONGU:
    FOR i=0 TO 255
        HPWM     1,DUTY,1000
        DUTY=DUTY+1
        PAUSE    50
    NEXT

    GOTO     DONGU
```

Programming in C

- Programming the PIC in C offers several advantages:
  - Higher level language – developer is insulated from details of the chip
  - Library support for common tasks (string manipulation, serial communication)
- We use the CCS compiler (http://www.ccsinfo.com/) which don't suck. All examples will use CCS code

PIC – Common Tasks with CCS

- Program Template. Starting point for just about everything

```
#define <16F877.h>     // Define the type of chip you're using.
                       // Makes it easier to switch chips
#use delay(clock=20000000)    // 20Mhz oscillator
void main()
{
        /* Initialization Code goes here */
        while (TRUE)
        {
                /* Program Code goes here */
        }
}
```

PIC – Common Tasks with CCS

- Digital I/O
  - Standard I/O vs. Fast I/O
  - Using (standard I/O):

```
// Output a high on PIN_D1, low on PIN_D2
// Wait 50 us and invert
output_high(PIN_D1);
output_low(PIN_D2);
delay_us(50);
output_low(PIN_D1);
output_high(PIN_D2);
```

PIC – Common Tasks with CCS

- Analog Input
  - Initialization:

```
setup_adc_ports(ALL_ANALOG);
setup_adc(ADC_CLOCK_DIV_2);
```

  - Picking a channel:

```
set_adc_channel(0);     // Note: must wait
  between changing
                  // input channels (~ 10us)
```

  - Inputting Data:

```
unsigned int16 data;    // Declare a 16-bit
  integer
data = read_adc();      // Read a 10-bit value
  from the                    // selected channel
```

PIC – Common Tasks with CCS

- Using PWM
  - Initialization:

```
setup_timer_2(T2_DIV_BY_1,249,1);   // Setup the
  PWM period
setup_ccp1(CCP_PWM);                // Set CCP1
  for PWM
```

  - Setting the Duty Cycle:

```
set_pwm1_duty(500);     // See the CCS examples
  for the formula             // for setting the
  PWM period and duty               // cycle
```

PIC – Tips for Software Design

- Design the program as a state machine
  - A main() loop, with:
    - A switch() statement that jumps to a function() which represents the actions that occur in that state
    - Each state function() has an output section and a transition section (which can change the current state variable)
  - Interrupts are very useful (for example: interrupt when data received on serial port), but can cause problems.
    - I.e. if you change state during an interrupt (such as an E-stop), return from the interrupt service routine, then change the state variable again (during the transition section) the interrupt change is lost.
  - Design with tuning and debugging in mind
    - Programmer time is more important than machine time – the PIC16F877 is plenty fast

PIC – Tips for Debugging

- Use a protoboard with RS232 support and lots of print statements. Example:
  - program waits for a switch press
  - reads an analog voltage
  - changes the PWM cycle accordingly

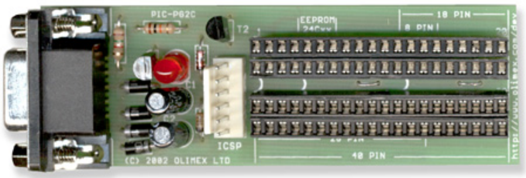
PIC – Tips for Debugging

```
Some_function()
{
    int1 pushed = FALSE, last_pushed = FALSE;
    int16 analog_value;
    float volts;
    pushed = input(PIN_D3);
    if (pushed && !last_pushed) {
          puts(“Button Pushed!”);
          analog_value = read_adc();         /* 10-bit analog input value is
                                              * between 0-1023 0-5V range */
          volts = 5.0 * (analog_value / 1024.0);
          printf(“Button pushed! Analog value is %f volts, PWM to %i\n, volts,
                              analog_value);
          set_pwm1_duty(analog_value);
          /* We’ve pre-configured PWM channel 1 – the set_pwm1_duty cycle
    function accepts
             a 10-bit number and adjusts the cycle accordingly */
    }
```

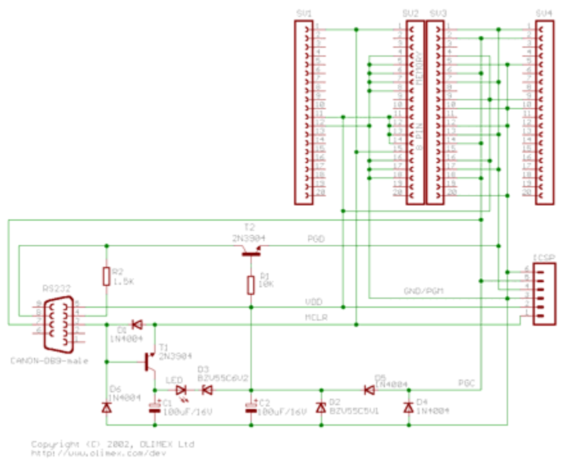
CHAPTER 4

PIC PROGRAMMERS

PIC-PG2 - SERIAL PORT PROGRAMMER FOR 8/18/28/40 PIN PIC MICROCONTROLLERS AND I2C EEPROMS + ICSP connector and cable



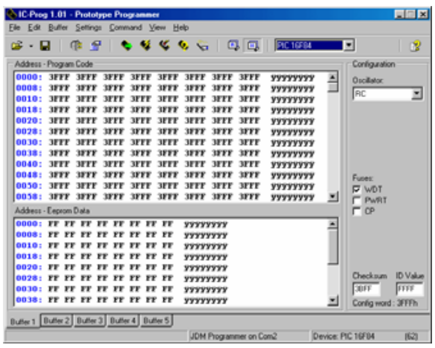
http://www.olimex.com/dev/pic-pg2.html



http://www.ic-prog.com/

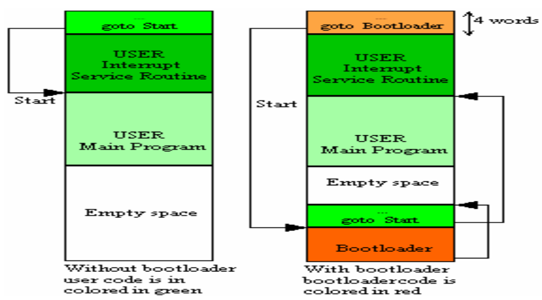
IC-Prog Prototype Programmer

Programs : 12Cxx, 16Cxxx, 16Fxx, 16F87x, 18Fxxx, 16F7x, 24Cxx, 93Cxx, 90Sxxx, 59Cxx, 89Cx051, 89S53, 250x0, PIC, AVR , 80C51 etc.

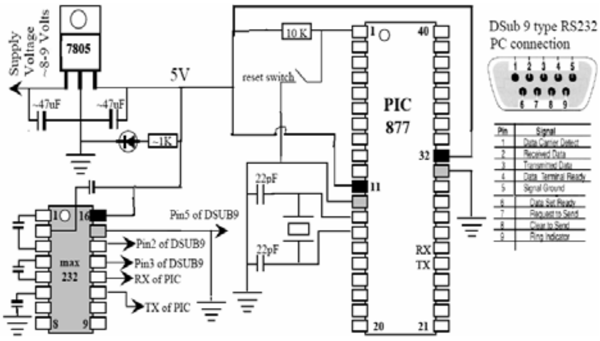


BOOTLOADER

A bootloader is a program that stays in the microcontroller and communicates with the PC (usually through the serial interface). The bootloader receives a user program from the PC and writes it in the flash memory, then launches this program in execution

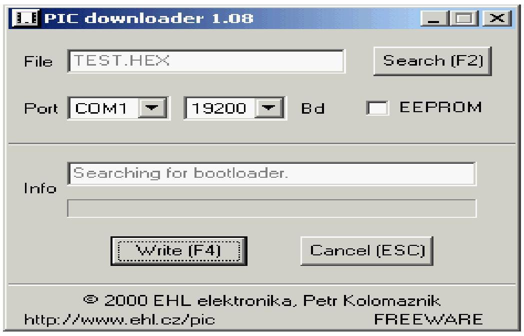


BOOTLOADER



- The PIC16F877 has on-board FLASH memory
  - No burner needed to reprogram the PIC
  - No need to remove PIC from circuit
- Using a bootloader on the PIC, and a bootload utility on the PC the PIC can be reprogrammed in seconds over a serial link.
  - Burn the bootloader code onto the PIC
  - When writing your program in C tell the compiler not to use the top 255 bytes of flash memory
  - Connect the PIC circuit to the PC via a serial link. Run the bootloader code from the PC and download your code to the circuit in seconds.

http://www.microchipc.com/PIC16bootload/

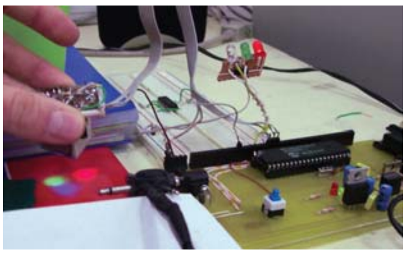


CHAPTER 5

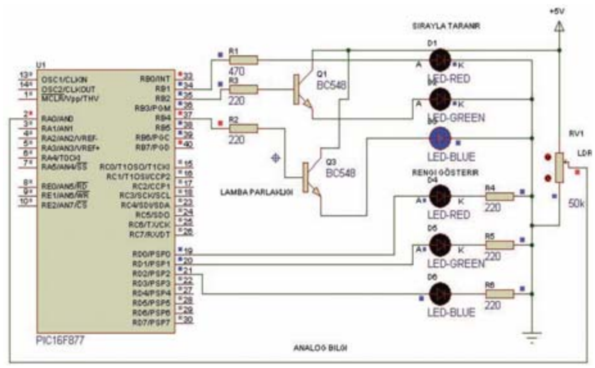
PIC ISIS SIMULATION APPLICATIONS

APPLICATION 1

PIC COLOR SENSOR



ISIS CIRCUIT SCHEME



DETAILS OF THE CIRCUIT

- Reads the color of the surface from the distance between 5-40mm. Three colors (red,blue,green) can detected and shown on red,blue,green indicator LEDs.

- Red,Blue,Green LED diodes emit lights, and the reflected light read with LDR. LDR output is converted to a digital value using ADC channel 0 of PIC.

```
DEFINE OSC 4                    '4 MHz clock
DEFINE ADC_BITS 8               '8 bit A2D
DEFINE ADC_CLOCK 3              'ADC Clock Adjust (rc = 3)
DEFINE ADC_SAMPLEUS 50
ADCON1 = 2                      'PORTA is analog input
INPUT PORTA.0
TRISB = 0
SYMBOL VERI = PORTA.0           'Analog Data
SYMBOL REDIND= PORTB.3          'Indicator REDLED
SYMBOL GREENIND = PORTB.5       'Indicator GREENLED
SYMBOL BLUEIND = PORTB.4        'Indicator BLUELED

SYMBOL RED = PORTB.0            'Scanner REDLED
SYMBOL GREEN = PORTB.1          'Scanner GREENLED
SYMBOL BLUE = PORTB.2           'Scanner BLUELED
DAT VAR BYTE                    'ADC out
DAT_R VAR BYTE
DAT_G VAR BYTE
DAT_B VAR BYTE
```

```
CLEAR
MAIN:
CALL READ_VAL
GOTO MAIN
READVAL:
HIGH RED
PAUSE 5
CALL ADC_RD
DAT_R = DAT
LOW RED
PAUSE 5

HIGH GREEN
PAUSE 5
CALL ADC_RD
DAT_Y = DAT
LOW GREEN
PAUSE 5

HIGH BLUE
PAUSE 5
CALL ADC_RD
DAT_B= DAT
LOW BLUE
PAUSE 5
IF DAT_R < BILGI_B && DAT_R < DAT_Y THEN
HIGH KIRMLED
LOW MAVILED
LOW YESILLED
ENDIF
IF DAT_G < DAT_B && DAT_G < DAT_R THEN
HIGH YESILLED
LOW MAVILED
LOW KIRMLED
ENDIF
IF DAT_B < DAT_G && DAT_B < DAT_R THEN
HIGH MAVILED
LOW KIRMLED
LOW YESILLED
PAUSE 20
ENDIF
RETURN
```

```
ADC_READ:
ADCIN VERI, BILGI
RETURN
```

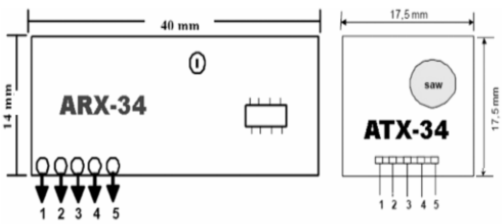
RGB VALUES

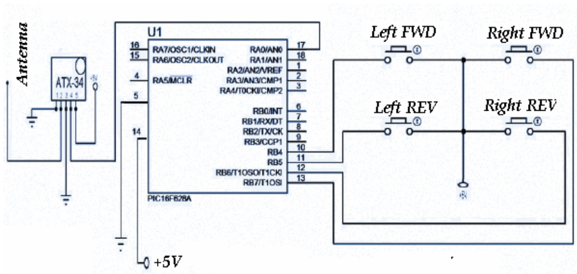
COLOR	RED	GREEN	BLUE
GLOSSY RED	3.14 V	1.23 V	1.11 V
DARK RED	2.99 V	1.45 V	1.36 V
DARK MATTE GREEN	2.24 V	2.89 V	3.11 V
LIGHT GLOSSY GREEN	1.27 V	3.78 V	3.37 V
MATTE GREEN	1.51 V	3.44 V	2.39 V
LIGHT MATTE BLUE	1.11 V	2.84 V	3.24 V
MATTE BLUE	1.23 V	2.87 V	3.17 V
DARK GLOSSY BLUE	2.22 V	2.57 V	3.36 V

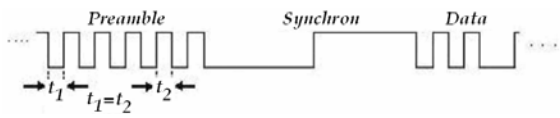
APPLICATION 2

RF CONTROLLED MOTOR

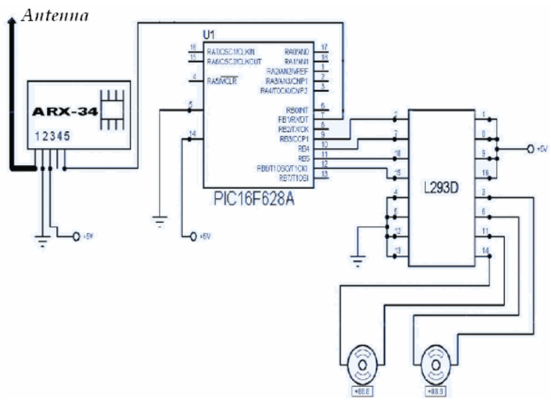
433,92 MHZ







```
CMCON=07      'PortA
INCLUDE "modedefs.bas"
OPTION_REG.7 = 1  'PortB Pull_Up Active
TRISB = %11110000
TRISA = %00000000
K VAR BYTE
K=0
PAUSE 500
Serout2 PORTA,0,16780,[REP$AA\5,REP$00\REP$FF\5]
; preamble + Synchron Sending
MAINLOOP:
IF PORTB.4=1 then K.BIT0=1
IF PORTB.5=1 then K.BIT1=1
IF PORTB.6=1 then K.BIT2=1
IF PORTB.7=1 then K.BIT3=1
SEROUT PORTB.7,N2400, [254]
SEROUT PORTB.7,N2400, [K]
SEROUT PORTB.7,N2400, [192]
PAUSE 16
K=0
GOTO MAINLOOP
```




```
CMCON=07     'PortA
TRISB = %00000010

DEFINE HSER_RCSTA 90h
DEFINE HSER_TXSTA 20h
DEFINE HSER_BAUD 2400
DEFINE HSER_CLROERR 1

LEFTFWD VAR PORTB.3
LEFTREV VAR PORTB.4
RIGHTFWD VAR PORTB.5
RIGHTREV VAR PORTB.6
K VAR BYTE
ERRCHK VAR BYTE
PAUSE 250

MAINLOOP:
HSERIN [WAIT(254),K,ERRCHK]
LEFTREV=0; RIGHTREV=0;
RIGHTFWD=0; LEFTFWD=0;
```

```
IF ERRCHK=192
THEN
 IF K.BIT0=1 THEN
    LEFTFWD=1
 ELSE
    LEFTFWD=0
 ENDIF

 IF K.BIT1=1 THEN
    LEFTREV=1
    ELSE
    LEFTREV=0
 ENDIF

 IF K.BIT2=1 THEN
     RIGHTFWD=1
     ELSE
     RIGHTFWD=0
 ENDIF

 IF K.BIT3=1 THEN
    RIGHTREV=1
    ELSE
    RIGHTREV=0
 ENDIF
ENDIF

PAUSE 10
GOTO ANADONGU
```

REFERENCES

- www.microchip.com (Official website of the PIC manufacturer, PIC16F877 datasheet & some application notes are avaliable)
- http://www.microchip.com/ParamChartSearch/chart.aspx?branchID=1002&mid=10&lang=en&pageId=74
- http://en.wikipedia.org/wiki/PIC_microcontroller
- http://www.jpixton.dircon.co.uk/pic/
- http://www.oopic.com/
- www.antrak.org (Ankara amateur radio society website)
- www.eproje.com (Some applications in Turkish)
- www.picproje.net (A discussion forum on PIC in Turkish)
- www.elektroda.pl (A discussion forum on PIC)
- robot.metu.edu.tr (METU Robot Society website)
- http://www.engr.mun.ca/~msimms/pic/ (code archive)
- http://www.workingtex.com/htpic/ (examples)

REFERENCES-2

- http://www.olimex.com/dev/pic-pg2.html
- http://sourceforge.net/project/downloading.php?group_id=599&use_mirror=heanet&filename=sdcc-2.6.0-setup.exe&40589420
- http://robot.metu.edu.tr/index.php?link=5
- http://www.tomshardware.com.tr/howto/20050909/index.html

C and bootloader links

- CCS PIC C Compiler
  - http://www.ccsinfo.com/
- CCS PIC C Compiler Manual
  - http://www.ccsinfo.com/piccmanual3.zip
- Bootloader Code (that resides on the PIC)
  - http://www.workingtex.com/htpic/PIC16F87x_and_PIC16F7x_bootloader_v7-40.zip
- Bootloader Program (that resides on the PC)
  - http://www.ehl.cz/pic/